APR 19 1926

SCIENCE

NEW SERIES
VOL. LXIII, No. 1633

FRIDAY, APRIL 16, 1926

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 8, 1879.

CENTENNIAL OF THE UNDULATORY THEORY OF LIGHT[1]

A HUNDRED years ago physical science received one of the greatest contributions ever made by a single man. This achievement was the establishment of the undulatory theory of light by the Frenchman, Augustin Fresnel. The work of this extraordinary man put the theory of optics on an entirely new foundation and inaugurated a steady evolution of this discipline which continues up to the present time. Beyond this, it had a stimulating and inspiring influence on other branches of physics having no apparent connection with the theory of light. It would be an interesting problem to look back on a century of scientific work and to analyze what concepts are due to Fresnel and how these concepts have stood the test of a hundred years. However, our present intention is a different one. A retrospective glance at the time of Augustin Fresnel and the scientific atmosphere in which he lived has still another purely human interest. It gives us an opportunity to trace step by step the resistance which a new and revolutionary idea finds in its way and to see how this resistance is gradually overcome. The fate of new concepts defying tradition is always the same: In the beginning they meet with a strong opposition rejecting them sometimes with cold disdain, sometimes with passionate irritability. Slowly and gradually the new theory obtains a reluctant acceptance. The contemporaries raised in different views finally resign themselves to it and only the following generation is in a position to admire and praise it without inhibitions.

The history of the undulatory theory is a classical example of this process. A hundred years ago the scientific public opinion was not such a complicated and widely ramified structure as to-day. Essentially it was represented by the opinion of five or six specialists associated with the Academy of Sciences of Paris. A discovery was accepted when its author had succeeded in convincing this handful of men. There are still numerous documents extant which give us all the necessary information about the attitude of the leading savants towards Fresnel's new theory. Science outside of France is almost of no avail for our problem. In Germany the experimental and theoretical study of nature was taken up a generation later and the conditions were similar in this country. In England there were several natural

[1] Read in a public session of the Astronomy and Physics Club of Pasadena, California.

philosophers of importance, but they were not interested in optics. An isolated figure was Thomas Young; as we shall bring out later, he anticipated some of Fresnel's first discoveries. But Young as a physician by profession was himself an outsider and not taken seriously by specialists. His influence was not sufficient to ease Fresnel's task appreciably.

Early science was guided in the explanation of the phenomena of light and vision by two analogies in the regions of better investigated sense perceptions. On the one hand, the phenomena of olfaction have their cause in material particles emanating from the fragrant body, which enter our organ of smell and produce in it the well-known sensations. On the other hand, the cause of sound is a wavelike or undulating motion of the air. Accordingly, two different views about the nature of light had from the very dawn of science their supporters among the philosophers. The emission hypothesis contended that a luminous body projects into space tiny particles which enter and affect our eyes. The undulatory hypothesis regarded light as a wavelike motion of a hypothetical medium which was supposed to fill all space and to penetrate all transparent bodies. This medium was named the *light ether*. Each hypothesis had had in the course of centuries a number of famous exponents. We find the emission hypothesis stated by Empedokles and among its supporters were Kepler, Newton and Laplace. On the other hand the undulatory hypothesis was preferred by Aristotle, Descartes, Hooke, Huyghens and Euler.

Sufficient experimental data for a mathematical theory of light were accumulated only about the end of the seventeenth century, mainly by Newton's discoveries. As we have mentioned, this great philosopher decided himself for the hypothesis of emission. Applying the principles of mechanics which he had recently discovered to the motion of the hypothetical light particles, he created the emission theory of optics. The idea of wave motion had to stand back for a whole century. In part this was due to the enormous authority of Newton's name, in part to some real advantages of his theory. This theory was clearly formulated and seemed fit to give precise answers to a few concrete questions, while the concepts of the undulatory hypothesis were somewhat vague and did not appear to offer points of attack for special applications. It is true that a famous Dutchman, Christiaan Huyghens, had laid some foundations for a future theoretical treatment of wave motions by enunciating a principle bearing his name. The gist of his contentions was that one can regard every point of a light wave, progressing through the ether, as an independent source of light. Huyghens's principle proved to be a wonderful tool in the hands of his successors with which they achieved almost miraculous results. However, the applications to which Huyghens himself put his method seemed to suffer from grave inner contradictions. Especially the rectilinear propagation of a light ray remained an inexplicable enigma to this point of view. Even a hundred years later in Fresnel's time his partisan Young wrote in a private letter: "If a ray of light has constantly such a tendency to diverge into the path of neighbouring rays as Huyghens assumes, then I don't see how, even in the most transparent medium, it can travel a way, howsoever short, without being completely extinguished." Therefore, the philosophers of the eighteenth century had serious, well-analyzed reasons for rejecting this doctrine. Only the great Swiss mathematician, Leonhard Euler, expressed himself in favor of the undulatory hypothesis, without, however, adding anything of importance to its theory. Thomas Young was the first to whom some progress beyond Huyghens's teachings is due. But the gigantic task of solving all the contradictions and of erecting a finished undulatory theory on the foundations laid by Huyghens required a genius like Fresnel's.

Augustin Jean Fresnel was born in the year 1788 in the small French town of Broglie as the son of an architect. He received a careful education under the guidance of his intellectual mother, but his delicate physique retarded his early development. He could scarcely read at the age of eight and his teachers were rather discouraged about his future. His playmates, however, had a more correct view of his personality, since to them he was known under the nickname "the genius." He owed this distinction to his technical ingenuity, which enabled him greatly to improve upon the construction of little cannons of elder wood. In fact, he brought this weapon to such a formidable perfection that its use had to be prohibited by a parents' meeting especially called for this purpose.

At the age of sixteen Augustin passed a brilliant examination into the École Polytechnique at Paris, and choosing civil engineering as his specialty received his technical training in the "Corps des Ponts et Chaussées." Having graduated after a five years' course, he was employed by the government in building state roads and had to spend several years in a complete rural solitude. To have a recreation and to divert his mind from the worries and frictions of his profession, he began to devote his spare time to research. In the beginning he was occupied by religious and philosophical problems. It was not until the year 1814 that at the age of twenty-six his attention returned to the difficulties which optics had presented to him during the time of his studies at the École Polytechnique. And soon he was absorbed in the endeavor to replace the theory of optics which then prevailed by a better one.

It is doubtful whether his trying professional work uld have left him the time to succeed. But politi- events that interrupted his engineering career for veral months gave him the leisure to devote himself mpletely to science during that period. Napoleon, o had been prisoner on the Island of Elba, sud- nly returned to France, and Fresnel joined as a unteer the little army that tried to stop the em- ror's progress. Being a state official he was sus- nded by Napoleon's ephemeral government, the so- lled government of the hundred days. He was, wever, permitted to choose as his temporary resi- nce the village in which his mother lived in re- ement. On his journey to this place he had the portunity of spending a few days in Paris and of nsulting several scientists, especially the astronomer d physicist Arago. It does not seem that Arago's vice was of any immediate assistance to him. evertheless he derived some encouragement from e friendly reception this savant gave him. Later e connection of these two men became highly benefi- l for themselves and for the progress of science.

In the seclusion of his mother's country place Fres- l devoted himself to the investigation of the phe- mena of *refraction*. He possessed neither a helio- t nor a micrometer, and had to improvise his paratus of wire and cardboard with his own hands. t even with such crude facilities he succeeded by ans of patience and good judgment in making mea- rements of sufficient accuracy to establish a few ws which these phenomena obey. The results of s work were two comprehensive papers which he used to be presented to the Academy of Sciences short succession. As we have mentioned, Huyghens d Euler had realized that light consisted of a riodic succession of waves. However, it did not cur to them that the effects of different waves uld influence each other. Thomas Young was the st to point out that in certain points the effects two waves could destroy each other, namely, when e crest of one wave is superposed on the trough the other. This mutual action is known at present the principle of interference. Young tried an ex- riment which has become famous; he proved by it e influence of two neighboring sunbeams upon each her, and gave also an adequate theoretical discus- on of this phenomenon. He was equally successful applying his principle of interference to explain- g the colors of thin films which had been thoroughly udied and described by Newton.

Young's beautiful researches had remained un- own to Fresnel. His first work practically mounted to the independent rediscovery of the prin- ple of interference and hardly contained anything ing beyond Young's contributions. This English ysician had been called by Helmholtz "the most penetrating mind that ever lived." Outside of his optical investigations we are indebted to him for the generally accepted physiological theory of color vision and for a decisive step in the deciphering of the Egyptian Hieroglyphics. It is characteristic of young Fresnel's talent that he recognized the principle of interference at first sight and passed through the whole optical life work of the great Englishman and beyond it at the first onset.

The Academy of Sciences charged Arago with the examination of the two papers presented by Fresnel. The first thing Arago did was to obtain for Fresnel a leave of absence, so that he could spend a few months in Paris and repeat his experiments with better facilities, in part in collaboration with Arago. Francois Arago, who has played such an important part in the history of optics by this intervention on behalf of Fresnel and by his subsequent association with him, was himself one of the most interesting figures of scientific France. The academy accepted him as one of its members at the unusually early age of twenty-three to indemnify him for the hardships, sacrifices and danger of life he had gone through on the occasion of the famous French-Spanish meridian measurement which was undertaken for determining the length of the meter. At the same time the emperor appointed him professor at the École Polytechnique. Neither the academy nor the government had to regret their choice, for Arago developed into the most famous and popular wizard of France. If we look over his scientific work to-day, we must admit that it is not quite sufficient to account for his unprecedented popularity. A large part of his reputation was based on the clearness of his delivery and on the art of humanizing science which he possessed to an unusual extent. It is said that in his lecture courses the scholar of note sat beside the layman without any preparation and each went home with profit and satisfaction. Indeed, it is a great merit to have made science generally accessible at a time when most of the specialists were inclined to enshroud it in a nimbus in order to hide it from the crowd. In the evening of Arago's life the people of France received their opportunity of proving to him their gratitude and respect: After the revolution of 1848 they elected him by acclamation into the provisional government and entrusted him with the departments of war and of the navy.

But even pure science was more indebted to Arago than appears from his collected papers. Having a quick comprehension, many-sided interests and an active, progressive mind, he entered into correspondence and personal contact with many leading men of science. His sterling character, free from jealousy and envy, favored the change of these relations into lasting friendships which joined him, not only with

French, but also with German and English scholars. He was, therefore, the very man to clear the way for an exchange of opinions between slower and more reserved minds who would not have found and enriched each other without him. Figuratively speaking, he was a ferment or catalyzer accelerating the process of scientific evolution.

When Arago was charged with the report on Fresnel's work he was thirty and had just founded in company with his intimate friend, the chemist Gay-Lussac, a new magazine, the *Annales de Chimie et de Physique,* which is still thriving at the present day. No sooner had he recognized Fresnel's unusual talent than he began to ease matters for him as energetically as he could. In the beginning of the year 1816 that young man arrived in Paris to repeat and extend his experiments with improved apparatus. With the help of the more accurate data so obtained, he recast the contents of his two papers into a new form which appeared as his first publication in March, 1816, in Arago's magazine. He sent a reprint to old Thomas Young, but it seems that Fresnel's work made no particular impression on this veteran of science. "Neither myself," he wrote to Arago, "nor the very few who are acquainted with my writings can find in it a single new fact of any importance." This sentence was unjust: there was in Fresnel's paper a brief reasoning by which he showed that light is reflected from a mirror only in one direction. This argument needed only to be combined with Huyghens's principle to solve immediately the enigma of rectilinear propagation of light. This step was carried out by Fresnel in his next publication, and then Young changed his opinion of the importance of the young scholar and expressed to him his appreciation in a flattering letter.

If Fresnel's first publication did not meet with the unreserved approval even of his partisan, Thomas Young, it is clear that it must have had still much less success with the opponents of the undulatory hypothesis, who held the majority in the Paris Academy of Sciences. President of this famous corporation was at that time the great Laplace, whom we have already mentioned as a distinguished adherent of the emission theory. Also Edouard Biot, the discoverer of the optical activity of liquids and of an electro-dynamical law bearing his name, had rigidly committed himself to the Newtonian theory by publishing a book in two big volumes in which the phenomena of polarization of light were treated from this point of view. Two more physicists of international reputation who belonged to the Academy, Ampère and Fourier, did not take a conspicuous part in the controversy, whilst the mathematician, Poisson, turned out to be a most exasperated adversary of Fresnel's contentions and of the undulatory theory.

Laplace and Biot were not in the least shaken in their convictions by the work of Young and of Fresnel. They regarded it as sure that a really exhaustive study of interference and diffraction could only lead to new triumphs of the emission theory so dear to their hearts. Therefore, when the question of the competition for the grand prize in mathematical sciences came up, they did not hesitate to propose for this competition the following problem: "A theoretical and experimental investigation of the phenomena of diffraction and interference." The prize problem was announced in March, 1817, and August 1 of the following year was appointed as date for turning in the competitive essays. The wording of this announcement clearly shows that its authors were prejudiced in favor of the emission theory and had no idea of the truth.

These circumstances were not encouraging for Fresnel's taking part in the competition. Only reluctantly he made up his mind to join it at the urgent instances of Arago and Ampère. His leave of absence in Paris had long since expired. During it he had shown an extraordinary productivity in ideas and experiments. But now he was detained in the city of Rennes by trying official duties which deprived him of the possibility of scientific work for a whole year. Not until the fall of 1817 was he granted a second leave of absence. Half a year later it was followed by a complete transfer to Paris, and there made scientific facilities permanently available to him. He finished and delivered in time his competitive paper. Only a small part of it was occupied by direct answers to the questions proposed by the academy. The bulk was devoted to a systematic summary of the theory of diffraction which we regard to-day as the classical presentation of this subject. Following Huyghens he divides a spherical wave into infinitesimal elements and regards each of them as a separate source of light. If we concentrate our attention on a point outside of this wave, it can be shown that this point is reached only by light coming from a minute part of the sphere which lies in the straight line connecting the center of the sphere with the point under consideration. The elements covering the rest of the sphere cancel each other in their action by interference. By this reasoning the enigma of rectilinear propagation of light is solved and the apparent contradiction in Huyghens's principle removed. The same type of argument remains valid when a part of the wave surface is screened off by opaque objects, and easily explains the formation of fringes at the border of the geometrical shadow. Fresnel carried through the numerical calculations in a few special cases and proved by experiments tried for this purpose the splendid agreement between theory and experience.

On the board of judges appointed by the academy ree influential adherents of the old theory were posed to Arago, the only representative of the w ideas. The chemist, Gay-Lussac, who also was the board, was completely non-partisan. Through s personal relations to the judges, Fresnel was kept formed about his chances, and by the letters he rote to his brother we can follow the oscillations the scales. A short time after turning in his aper he complains of Laplace's negative attitude, d then goes on as follows:

> In a conversation which I recently had with Poisson admitted to me that the many disconnected hypotheses curring in the Newtonian theory had diminished his nfidence in it to a considerable extent. I hope that the rusal of my paper will bring him on the side of the dulatory theory. Mr. Biot, who did read this paper d who knows the difficulties of the emission system tter than anybody else, is the one whose conversion ems to me the nearest. It is a pity that because of his ok he finds himself in a position so strongly biassing s ambition in favor of that theory. As to *Arago*, is much satisfied with my theory of diffraction, and I lieve that *Gay-Lussac's* opinion of it is about the same.

Unfortunately the favorable impressions which resnel had of his chances was due to the optimism his youth, and his faith in scientific conversions rned out to be premature.

The deliberations of the board were progressing owly. As Fresnel quite correctly remarked, not ly the award of a prize, but a complete scientific volution was at stake. We shall be able to esti- ate what formidable resistance had to be overcome we occupy ourselves with the personality of the st influential of the judges. Peter Simon Marquess Laplace had already reached the age of seventy hen he came into contact with Fresnel. Having sen from small beginnings to the highest offices d honors, and become the pride of France, he atched his fame with jealousy and did not like ing eclipsed by anybody else. As president of the eademy of Sciences, member of the French Acad- my, honorary member of almost every academy and cientific society of Europe and America, the great an could not complain of being too little appre- ated. After Lagrange's death there was no mathe- atician in the whole world who could come any- here near him in reputation and authority, and evertheless he was susceptible in a surprising de- ree to the feeling of rivalry and scientific jealousy. haracteristic for this is an episode from Arago's ecollections, who for a short time was Laplace's as- stant at the observatory and therefore a frequent uest in his house. "The son of Mr. de Laplace," lated Arago, "was preparing himself for the ex- minations at the École Polytechnique, and he often ould call on me at the observatory. On the occasion of one of these visits I explained to him the method of continuous fractions by means of which Mr. Lagrange finds the roots of numerical equations. The young man talked with admiration about this to his father. Never shall I forget the rage into which the latter was put by his son's words, nor the bitterness of the reproaches he addressed to me for having advocated that method, which as everybody knows, is beyond criticism as to elegance and rigor. Never had prejudice shown itself less disguised and in a harsher form. 'Alas,' I said to myself, 'how right were the ancients attributing failings even to him who shook Olympus with his frown'."

It is, therefore, easy to understand that the academic honors and distinctions heaped upon Laplace could soothe his vanity as little as the shower of decorations descending upon him. His ambitious nature was craving for political power. The opportunism and complete lack of principles which he showed in this pursuit were blamed by many contemporaries. A republican at the time of the first republic, he became after the revolution of the 18 Brumaire home secretary or minister for the interior of the first consul. In this capacity he proved a complete failure. Napoleon used to say that "he carries the spirit of the infinitesimal into politics," and dismissed him after six weeks. However, he filled, during the consulate and empire, other important offices, having been made president of the Senate and Grand Officer of the Legion of Honor, and created a count. This did not prevent Laplace from turning an archreactionary after the restoration and becoming a marquess and a peer of France.

The influence of Laplace's mentality on his attitude toward Fresnel and the undulatory theory is obvious. Laplace was almost as great a physicist as mathematician. Among other things he had paid a great deal of attention to optics, and believed that he had explained a number of new facts from the point of view of the emission theory. If it is hard for every man to relinquish at an advanced age the convictions of long years, and to turn over a new leaf, this applied to Laplace in an increased measure. He had acquired a certain right to regard his own opinions as more valuable than those of other people and was confirmed in this by his vanity. Therefore, he felt little desire to enter into ideas foreign to him, least of all into those of such a young man and scientific beginner as Fresnel. After a conversation with Laplace the latter wrote to his brother, "I understand that M. de Laplace does not pay any attention to what one says to him," and in another letter: "M. de Laplace, who reads very little, had not the patience for reading through my thick paper from end to end. He requested Arago to prepare an abstract of it for him."

It is hard to say what the decision of the judges would have been if an unforeseen event had not given a new aspect to the matter. From the form of the integrals by which Fresnel had expressed the distribution of light in the geometric shadow, Poisson had recognized that the middle of the shadow cast by an opaque circular screen should be just as bright as if there were no screen at all. Fresnel was summoned and invited to account for this. He tested this point experimentally and the experiment gave a striking confirmation of the paradoxical conclusion from his theory. Including this success, the new doctrine could boast of so many cases of agreement with experiment that it could no longer be ignored. Though the judges were very far from sharing Fresnel's views, they made up their minds to award the prize to Fresnel, especially as there was no other competitor of merit. It is hardly necessary to say that history has ratified this decision. We regard at present Fresnel's winning essay as a classic. Its study can be highly recommended, being not only enjoyable but also profitable and stimulating even in our days. It is possible that Laplace, the only mind among the judges equal to Fresnel's, had a suspicion of the historical significance of this episode. It seems that in the dilemma of conquering his vanity or of impairing his reputation in the eyes of posterity, he consciously chose the first course.

This view is suggested by the fact that during the second period of Fresnel's scientific activity, his way was smoothed by Laplace in every possible respect. The researches of this second period were devoted to the phenomena of polarization and are based on an additional hypothesis by which Fresnel had completed and extended the undulatory theory, namely, on the assumption that the vibrations of light are not taking place in the direction of the ray, but at right angles to it, that they are *transverse,* as Fresnel put it. His previous results were not affected by this assumption. Both Huyghens's principle and the idea of interference which formed the bases of the earlier conclusions require only the *existence* of vibrations; in this connection their orientation is quite immaterial.

The concept of transversality on which Fresnel had ingeniously erected the whole structure of crystal optics was regarded as a mechanical impossibility by his contemporaries and met with strong opposition. Arago, who in August, 1822, reported to the academy about Fresnel's most important paper, dwelt with much approval on its experimental side, but passed over the theoretical part in silence. After Arago had finished, Laplace addressed the assembly; he congratulated the author on his beautiful results achieved by perseverance and sagacity, and declared that he esteemed these investigations above everything that had been presented to the academy for many ye

The patronage of Laplace and the friendship Arago opened to Fresnel the access to the hig honor which the academy had to award. On M 12, 1823, he was unanimously elected a member that body. Because of failing health his scienti productivity declined after his election. His l paper on optics was published in the beginning 1826; it marks the completion of his life work a seems, therefore, the appropriate date from wh to count the establishment of the undulatory theo

However, it would be a mistake to assume th this theory was established in the minds of his co temporaries. Fresnel's election to the academy w due to his numerous experimental discoveries wh importance nobody could deny, while the theoreti views that had led him to these discoveries were st the subject of passionate controversy. Even his mo friendly colleagues did not get beyond the stage indulgence in their relation to the undulatory theo and were very far from becoming its warm-heart supporters. I should like to recall to you Fresne letter from the time of the prize competition in wh he speaks about Laplace, Arago, Poisson and Bi and expects their rapid conversion. What were th actual opinions of these men? We have already su gested that Fresnel's work must have shaken L place's faith in the Newtonian theory. Howeve Laplace never made a public or private statemen to this effect. In the fourth edition of 1813 of h book "Exposition du système du monde" a whol chapter was devoted to a summary of the Newtonia theory of light. From the fifth edition of 1824 th chapter had simply vanished. Instead we read i the preface: "In the last edition I had presented th main results of the analytical theory of optics. A this field has since considerably increased I intend t treat it in a separate book." This book never ap peared. Arago, whom we know as Fresnel's mos faithful supporter during the first period of hi work, did not, to the very end of his life, becom reconciled with the idea of transverse vibration Even in 1852, twenty-five years after the death of hi great friend, he wrote: "From the moment whe Fresnel introduced transverse vibrations I refused t follow him." The most passionate opponent of th hypothesis of transversality was, however, Poisso He resisted it with all his might, as well by word o mouth in the Philomathic Society of Paris, as i print in the *Annales de Chimie et de Physique.* Th description of Poisson that has been handed dow to us is not quite free of contradictions. On the o hand, he is represented to us as a stout gentlem with a rosy, benevolently smiling face. The cha on which he sat and the desk at which he wrote we his whole world. Only once in all his life could h

family prevail upon him to make a journey. Every day he repeated his motto: "There are only two fine things in life: studying mathematics and teaching mathematics." On the other hand, we see him occasionally in a state of irritability and bad temper. His rivalry with Fourier sometimes assumed an undesirable form and in his polemic with Fresnel he was also often harsh and unjust. We can understand that the insufficient mechanical arguments by which Fresnel had tried to support his hypothesis could have offended him as a mathematician. But it is strange that he had no eye for the physical proofs produced in hundreds of experiments. However, the close study of Fresnel's ideas had a very strong influence on Poisson's later work, though he never admitted this. In his paper of 1830 on the propagation of sound in elastic bodies he pays equal attention to the transverse and to the longitudinal waves.

More than anybody else Biot had identified himself with the views of the emission theory, and its extension for the phenomena of polarization was essentially his work. Like Poisson, he started a polemic with Fresnel which, however, did not present much of interest. Nevertheless, Biot was the only one of the group who in later years, long after Fresnel's death, succeeded in a complete acceptance and assimilation of his theory. In 1846 Fresnel's brother, who was preparing for print an edition of Augustin's collected writings, had to examine some posthumous manuscripts in collaboration with Biot. In this connection he relates the following episode:

> Mr. Biot, after having expressed in warm words his high appreciation of Augustin's personality and his regret of not having come in closer social contact with him, dwelt with much emphasis on his scientific work. After a few moments' hesitation he proceeded with more animation as if moved by overwhelming thoughts: "What a marvelous power of intuition did your brother show in his fruitful concept of transverse vibrations!" One can imagine my surprise and emotion at this exclamation of the famous old man whom I had always regarded as one of the greatest fanatics of the Newtonian theory.

In the later development of optics it became known through the work of Maxwell and Hertz that the vibrations of light are not of a mechanical, but of an electromagnetic nature. Fresnel's theory was not affected by this as it implies only the existence of vibrations and their transverse character. Another crisis in our ideas of the nature of light is taking place at present, but under the name of the principle of correspondence we are still using and will continue to use the whole body of Fresnel's analysis. Again, as in Maxwell's time, the mathematical theory remains practically unchanged and only its physical interpretation is under discussion.

There is not much to say about the outer circumstances of Fresnel's life. As a governmental engineer he was assigned to the department of lighthouses in view of his optical propensities. These duties were not a sinecure. Important progress in the construction of searchlights is due to Fresnel, and his writings on this subject fill one of the three volumes of his collected papers. Taking into account that he acted at the same time as examiner at the École Polytechnique, it is astonishing how he could afford the necessary energy and time for his enormous scientific work. His health, always delicate, could not resist this strain. In the last years of his life frequent indispositions did not leave him time enough to divide it between science and official obligations. Devoted to his duty he decided in 1824 with a heavy heart to give up the main part of his scientific work. In the beginning of 1827 he was obliged to petition also for relief in his office by allowing him an assistant in the person of his brother. But it was too late: four months later he expired at the age of thirty-nine in the arms of his mother.

Fresnel's contemporaries did justice to his personality and to his scientific fervor. They were not able to appreciate the greatness of his work, which became apparent only to posterity, as the relative height of mountains can be judged only from a distance. I thought to-day a good opportunity to let pass before your eyes Fresnel's life and the fight he had to lead for his ideas a hundred years ago.

PAUL S. EPSTEIN

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THE CONDITION AND NEEDS OF SYSTEMATIC MYCOLOGY

THE subject of mycology is of such vital concern not only in connection with its many practical and important relations to human industry and activity, but also in the fundamental problems of biology, as to deserve much greater and more careful attention from student and teacher, as well as from the general scientist, than it receives at present.

Interpreted in its broader sense as including the study of bacteria and yeasts, as well as the multitude of parasitic and saprophytic fungi, mycology is of vast economic and scientific significance. The bacteria in relation to plant and animal diseases, the yeasts in connection with important industrial processes and the parasitic fungi in their relation to agriculture by the destruction of growing crops, stored food and other products, merely constitute a few of the important practical aspects of the subject. With respect to purely biological problems, such as phylogeny and evolution, the fungi offer especially favorable material for research, as various aspects and

phases of these problems can be attacked with greater hope of success by using organisms of simple structure, which can be easily and rapidly grown under artificial conditions that permit of the most rigid control and measurement.

Notwithstanding the great significance of the fungi, students of their taxonomy have been and are comparatively few, and they are often but poorly prepared for their work. The vast number of fungi concerned, of which nearly one hundred thousand supposed species have been described, and the many pleiomorphic and minute forms offer numerous and perplexing problems in the way of identification and classification. However, the facilities for thorough study in this field have increased rapidly in recent years, and with our present laboratory, library and herbarium equipment, and the increased opportunity for travel and collection, little excuse can be found for the hasty and superficial work frequently published.

What is the reason for the present dearth of investigators and students in this vast and interesting field and the inferior quality of much of the work? In Europe, general students of fungi and amateurs are much more numerous than in this country. This seems to be due, in part at least, to the better textbooks and field manuals available. In our haste for specialization in this field, as in others, the needs of the general botanist, the student and the amateur are overlooked or neglected.

Adequate and effective progress in mycology, as in all other sciences, depends upon the stimulation of interest in those who may be able to contribute toward it either in the way of research, field observation and the collection of material, or in general interest or moral and financial support. In order to secure such interest and cooperation, professional mycologists must have high ideals of research and service, in addition to a broad and thorough knowledge of the subject, which should be made available to all that desire it.

Attractive and reliable books on the taxonomy of the fungi are greatly needed, especially such as are adapted to the use of the student and general botanist, as well as comprehensive and thoroughgoing monographs. These can be properly prepared only by those who have devoted many years to the study of the subject in field, laboratory and herbarium and have had exceptional facilities in the way of literature and specimens.

Two great deterrents to students, as well as to general botanists and other plant scientists, are the lack of uniformity and stability in the use of Latin names and the endless subdivision and duplication of genera and species. With the continuous changing of names by different workers, in addition to the shifting interpretations and applications made of the same name, it is impossible for the student or general worker to take up the subject with any degree of interest or satisfaction. Accompanied as this is by the constant destruction of generic and specific landmarks and by the avalanche of so-called genera and species that exist only in the mind of the describer, it is not strange that mycology languishes.

It is patent that these two handicaps must be at once diminished, and ultimately removed, if mycology is to command respect and scientific support and render the practical service that it should. The selfish and myopic interests of a few specialists can not be allowed to override those of the much larger group that needs and would welcome a scientific and usable systematic mycology. New objectives and new methods with broader training and experience are demanded, and these can be secured only by building upon the best practice and knowledge already available.

Unfortunately, there are still fundamental differences of opinion as to how the problems of nomenclature can be most quickly and satisfactorily settled. Since the late nineties, priority of publication has been somewhat generally adopted as the basis for a choice of names. However, after a thorough trial this method has proved a failure, for reasons that have been given elsewhere.[1] Some have suggested that the nomenclature of the latest monograph of a group should be followed. This gives no greater promise of securing the desired result, because the monographer usually selects names according to individual preference or adherence to some particular code. Monographers are much given to expressing their individuality through changes of names and rarely if ever do two monographers of a group employ the same nomenclature, so that neither uniformity nor stability is reached by such a plan.

In view of this situation, we believe that the quickest and simplest method of securing stability and uniformity in the use of the names of fungi is to follow general usage. This may at first appear to be an indefinite and uncertain basis, as there is at present considerable difference in practice in different cases and by different mycologists. However, we feel that a committee of mycologists familiar with the principal systematic mycological literature of the world could prepare a list of species and genera on this basis that would be acceptable to the majority of users. When fixed by the citation of a particular species as the nomenclatorial type of each genus and a particular specimen as the type of each species, a fairly uniform and satisfactory nomenclature of the fungi should be assured.

[1] C. L. Shear, "Failure of the Principle of Priority to secure Uniformity and Stability in Botanical Nomenclature," SCIENCE, 60: 254–258, September 19, 1924.

Such a committee should also have some jurisdiction over the systematic units, especially genera and species. The constant multiplication of these is much more subversive of uniformity and stability than the mere changing of names.[2] Even the specialist finds it sufficiently discouraging to have to remember two or more names for the same unit, but when the unit is also wiped out, whether it be genus or species, by the superficial methods of current segregation, the result is chaos. If the units thus produced were a consequence of thorough field and experimental study and were capable of practical application, the values obtained might outweigh the confusion introduced, but this is practically never the case, and a bad situation is made worse by the complete neglect of evolutionary and phylogenetic values, which should be paramount in any taxonomy worthy the name. The best usage of conservative taxonomists since the time of Linnaeus affords the only possible basis for making mycology of definite and far-reaching service and for converting it into a real science based upon evolution and relationship.

Unless it adopts these objectives as its own, systematic mycology with its perpetual changing of names and its futile splitting and duplication of genera and species will fall into even greater disfavor and will continue to be ignored by general botanists and specialists in other lines of plant science and to be regarded with apathy by student and amateur alike. If those who regard the best usage as a feasible basis will support the plan suggested, order may yet be brought out of the present chaos of names and units, and the time and energy of mycologists can be devoted to the many basic problems that are in such great need of thoroughgoing research.

C. L. SHEAR
F. E. CLEMENTS

SCIENTIFIC EVENTS

EXPEDITION TO CENTRAL AMERICA TO STUDY THE HOOKWORM DISEASE

PLANS have been completed for a research expedition to Central America under the leadership of Dr. W. W. Cort, professor of helminthology at the Johns Hopkins School of Hygiene and Public Health, for the purpose of improving control measures used in combating the hookworm disease. The expedition is part of a program of cooperation which is being carried out between the department of medical zoology at Hopkins and the International Health Board of the Rockefeller Foundation.

This year's commission to Central America will be divided into two groups, one of which will go to Panama and the other to Nicaragua. One group, which will sail from New Orleans about the first week in June, will consist of Dr. D. L. Augustine, assistant professor of helminthology at Harvard University, and Dr. W. A. Riley, professor of animal biology at the University of Minnesota. The other group, which will leave New York for Nicaragua the latter part of May, will consist of Dr. N. R. Stoll, associate in helminthology in the Johns Hopkins department of medical zoology; Harold Brown, assistant in helminthology at Hopkins, and Dr. Maurice C. Hall, chief of the zoological division of the U. S. Bureau of Animal Industry.

Dr. Cort will divide his time between the two groups so as to coordinate the work.

This expedition will be the fourth taken under Dr. Cort's direction. In 1921 a commission was sent to the Island of Trinidad, in the British West Indies, by the Rockefeller Foundation, to make a scientific study of diseased localities there. The following year Porto Rico was the chosen field of investigation, and in 1923 a commission was sent to China, where fourteen months were spent in research work.

In both Nicaragua and Panama, the commission will be assisted in its work by officers of the health department, a number of local physicians, and staffs of native technicians trained in campaigns against disease.

The two parties of investigators will continue their work throughout the summer and will return early in October.

NATIONAL RESEARCH FELLOWSHIPS IN THE BIOLOGICAL SCIENCES

THE Board of National Research Fellowships in the biological sciences, at its recent meeting on February 27, made the following appointments and reappointments for the year 1926–27:

REAPPOINTMENTS

J. N. Couch—Botany
W. N. Ezekiel—Botany
H. W. Feldman—Zoology
T. N. Jenkins—Psychology
M. F. Metfessel—Psychology
Nellie M. Payne—Zoology
A. M. Showalter—Botany
Lee E. Travis—Psychology
Mildred Trotter—Anthropology
Conway Zirkle—Botany

NEW APPOINTMENTS

C. Dale Beers—Zoology
David Brunswick—Psychology
Kenneth Cole—Biophysics

[2] F. E. Clements, "Research Methods in Ecology," p. 12, 1905; "Ecologic View of the Species Concept," *Am. Nat.*, 42: 253, 1908. H. M. Hall and F. E. Clements, "Phylogenetic Method in Taxonomy," p. 2, 1923.

S. F. Cook—Botany
A. S. Foster—Botany
Albert H. Gee—Biochemistry
R. E. Girton—Botany
S. M. Gordon—Biochemistry
E. D. Hutchinson—Psychology
H. D. Kruse—Biochemistry
W. C. Olson—Psychology
E. Quisumbing—Botany
W. D. Strong—Anthropology
Paul T. Young—Psychology
R. L. Zwemer—Zoology

A second meeting of the board to consider additional applications for the year 1926–27 is planned for the middle of May. Information and application forms may be obtained from the Secretary, Board of National Research Fellowships in the Biological Sciences, National Research Council, Washington, D. C.

OIL AND GAS POWER NATIONAL CONFERENCE

IN keeping with the action of Secretary of Commerce Hoover in encouraging industry to stimulate research, a large group of technical societies are participating in the Oil and Gas Power National Conference with a nation-wide program of meetings during the week of April 19 through 24.

The purpose of the conference is to focus the attention of physicists, chemists, engineers, operating men and industries on the recent progress and immediate possibilities in the utilization of oil and gas for power purposes. The program includes over seventy-five gatherings at industrial centers where the scientific production and economic problems related to internal combustion engines and their fuels will be discussed.

Many new developments will be presented for public discussion and criticism, one of which will be the application of the high speed Diesel engine for automotive traction service. The extensive application of the Diesel engine to locomotive practice which is now in process, the design of oil engines for stationary power plants and the increasing use of Diesel engines in marine work are some of the topics that will receive attention. One feature of the conference meetings is the large number of papers prepared in plain terms to reveal the rapid advances in the application and use of internal combustion engines for power purposes.

A prize of $100 will be conferred on the writer of the paper that best fulfills the objects of the conference. The award will be made by a committee of outstanding chemists and engineers.

The societies participating are:

American Chemical Society, Local Sections
American Engineering Council
American Institute of Consulting Engineers
American Institute of Mining and Metallurgical Engineers
American Mining Congress
American Petroleum Institute
American Society of Agricultural Engineers
American Society of Marine Designers
American Society of Mechanical Engineers
American Society of Naval Engineers
Affiliated Technical Societies of Boston
Chemical and Engineering Schools and Colleges
Detroit Engineering Society
Engineers' Club of Cincinnati
Engineers' Club of Philadelphia
Engineers' Club of Trenton
Engineers' Society of Milwaukee
Engineers' Society of Western Pennsylvania
Louisiana Engineering Society
National Association of Stationary Engineers
National Board of Fire Underwriters
National Research Council
National Safety Council
Rochester Engineering Society
Society for Promotion of Engineering Education
Society of Industrial Engineers
U. S. Bureau of Standards
U. S. Geological Survey

The General Committee is composed of: L. H. Baekeland, Fred M. Becket, G. K. Burgess, H. L. Doherty, W. F. Durand, J. E. Edgerton, H. L. Horning, Arthur D. Little, Fred R. Low, Chas. E. Lucke, D. A. Lyon, J. V. W. Reynders, George Otis Smith, Bradley Stoughton, John E. Teeple, Guy E. Tripp.

The Steering Committee consists of: D. H. Killeffer, *chairman*, 29 West 39th Street, New York; Edgar J. Kates, Julius Kuttner, L. H. Morrison, R. L. Welch.

APRIL 5, 1926

THE OXFORD MEETING OF THE BRITISH ASSOCIATION

THE PRINCE OF WALES will deliver the presidential address to the British Association for the Advancement of Science this year at the meeting at Oxford, which takes place from August 4 to 11. The proceedings will be opened on the evening of August 4, in the Sheldonian Theater, when the Prince is expected to deal with the relations between scientific research, the community and the state, both at home and in the oversea dominions.

There are thirteen sections of the association which will meet daily, and in addition there are evening lectures, both for members and for the general public. Professor A. S. Eddington, professor of astronomy at the University of Cambridge, has promised to give one of the lectures to members, and the speakers already arranged for the public lectures include Captain Eckersley, who will deal with wireless questions, Professor Julian Huxley and Mr. P. F. Kendle, who will speak on some aspect of coal. Professor F. O. Bower will give a review of botany, contrasting it as

it is now with its position on the two previous occasions when the British Association met in Oxford. The title of his address will be "1860–1894–1926." Mr. Ormsby-Gore, M.P., will speak on the economic development of British Tropical Africa, and Sir John Snell on the future of electricity supply.

Receptions are to be held by the vice-chancellor of the university and by the mayor of Oxford in the examination schools and the Town Hall, respectively, on Thursday evening, August 5; and a *conversazione* given by the local executive committee, with the cooperation of the Junior Scientific Club, will be held in the University Museum and the Ashmolean Museum, on Tuesday evening, August 10.

The following sectional presidents have been appointed by the council:

Section A (mathematics and physics), Dr. A. Fowler, research professor of the Royal Society; section B (chemistry), Dr. J. F. Thorpe, professor of organic chemistry in the Imperial College of Science and Technology; section C (geology), Dr. S. H. Reynolds, professor of geology in the University of Bristol; section D (zoology), Dr. J. Graham Kerr, Regius professor of zoology in the University of Glasgow; section E (geography), Mr. W. Ormsby-Gore, parliamentary under-secretary for the colonies; section F (economics), Sir Josiah Stamp; section G (engineering), Sir John Snell, chairman of the electricity commission; section H (anthropology), Dr. H. J. Fleure, professor of geography and anthropology in University College of Wales, Aberystwith; section I (physiology), Dr. J. B. Leathes, professor of physiology in the University of Sheffield; section J (psychology), Dr. J. Drever, reader and Combe lecturer in psychology in the University of Edinburgh; section K (botany), Dr. F. O. Bower; section L (education), Sir Thomas H. Holland, rector of the Imperial College of Science and Technology; section M (agriculture), Sir Daniel Hall, chief scientific adviser to the Ministry of Agriculture.

SCIENTIFIC NOTES AND NEWS

DR. CHARLES C. ADAMS, professor of forest zoology and director of the Roosevelt Wild Life Forest Experiment Station of the New York State College of Forestry, Syracuse, has resigned, to become director of the State Museum, of the University of the State of New York at Albany. He succeeds the late Dr. John M. Clarke.

LUTHER BURBANK, internationally known for his work in horticulture, died at his home in Santa Rosa, Cal., on April 11, aged seventy-seven years.

THE Huxley memorial medal of the Royal Anthropological Institute of Great Britain has been conferred for the year 1927 upon Dr. Aleš Hrdlička, curator of the division of physical anthropology in the U. S. National Museum. Dr. Hrdlička will go to London in November, 1927, to deliver the Huxley lecture before the institute and receive the medal.

THE Hayden Memorial Geological Award of the Academy of Natural Sciences of Philadelphia was presented to Dr. William Berryman Scott, professor of geology at Princeton University, at a meeting of the academy on April 13.

THE Washington Academy of Sciences held a joint meeting with the Philosophical Society and the Biological Society on April 15, in the Cosmos Club. On behalf of the American Geographical Society, presentations were made of the Cullum geographical medal to Dr. Harvey C. Hayes and of the Charles F. Daly medal to Brig. Gen. David L. Brainard. Dr. P. R. Heyl, of the U. S. Bureau of Standards, delivered an address on "Visions and Dreams of the Scientific Man."

DR. WILLIAM BLUM, chief of the electro-chemistry division at the U. S. Bureau of Standards, will receive the medal awarded this year by the American Institute of Chemists for outstanding contributions to science in the public service. The presentation of the medal will be made at the annual meeting of the institute in the Chemists Club, New York, on May 8. Dr. Blum was notified of his selection for the award by a number of chemists who gathered at the Bureau of Standards on May 6. The announcement was made by Dr. R. H. Bogue, professor of chemistry at Lafayette College, in a short speech to which Dr. Blum responded.

THE Royal Geographical Society has announced the following awards: The Founder's Medal to Lieutenant-Colonel E. F. Norton, for his distinguished leadership of the Mount Everest Expedition, 1924, and his ascent to 28,100 feet; The Patron's Medal to Professor Sir Edgeworth David, for his work on the Funafuti atoll, and with Sir Ernest Shackleton's Antarctic Expedition of 1907–09, as leader of the first ascent of Mount Erebus, and of the party which first visited the South Magnetic Pole; The Victoria Medal to Dr. John Ball for his Desert Surveys and Memoirs on the Geography of Egypt; The Murchison Grant to Mr. Frank Debenham for his contributions to the scientific exploration of the Antarctic; The Back Grant to Afraz Gul for his surveys in Central Asia and Hunza; The Cuthbert Peek Grant to Major Kenneth Mason to assist his further exploration of the Himalaya; and The Gill Memorial to Dr. H. Gordon Thompson for his journey on the Tibetan and Mongolian borders of China with Brigadier-General George Pereira.

CHARLES M. ALLEN, professor of hydraulic engineering at the Worcester Polytechnic Institute, has been elected president of the Boston Society of Civil Engineers.

Dr. Edward R. Weidlein, director of the Mellon Institute of Industrial Research, University of Pittsburgh, and Dr. R. A. Gortner, professor of agricultural biochemistry at the University of Minnesota, have been appointed research consultants in the chemical warfare service of the United States Army.

Dean Franklin Moon, of the New York State College of Forestry at Syracuse; E. M. Leads, president of the Massachusetts Agricultural College, and George T. Carlisle, president of the Carlisle Paper Company, Bangor, Me., have been appointed by Secretary Jardine as members of the Northeastern Forest Research Council.

Professor Aladine Cummings Longden, who for twenty-five years has been at the head of the department of physics at Knox College, retires at the close of the present college year.

Dr. F. R. Bichowsky, of the Johns Hopkins University, has been appointed consultant in thermochemistry to the U. S. Bureau of Standards.

Dr. Afranio do Amaral, assistant in the Butantan Institute of Sao Paulo, Brazil, has been invited to organize a section for the study of animal poisons, toxins and antitoxins in the Institute of Tropical Biology and Medicine of Harvard University.

Dr. Auguste Pettit, of the Pasteur Institute, Paris, has accepted an invitation to take charge of the tuberculosis research work to be carried on at the University of Montreal, in connection with the dominion-wide program, planned by the Research Council of Canada.

R. S. Vose has left the research laboratory of the Institute of American Meat Packers to accept a position in the organic research division of the Mallinckrodt Chemical Company, St. Louis.

Professor S. C. Harland, of the Imperial College of Tropical Agriculture, has been appointed head of the department of genetics on the staff of the cotton research station of the Empire Cotton Growing Corporation at St. Augustine, Trinidad. Other appointments to the same staff are: Dr. T. G. Mason, to be head of the department of plant physiology; Mr. J. B. Hutchinson, assistant geneticist, and Dr. E. J. Maskell, assistant plant physiologist, who will leave England on April 17 for Trinidad.

G. N. Collins and F. E. Kempton, of the U. S. Bureau of Plant Industry, sailed on March 17 for Haiti, for the purpose of inaugurating experiments with maize hybrids. They plan to remain five or six weeks and cover the region between Port au Prince and Cape Hatien.

At the invitation of the universities of Paris and Berlin, Professor M. Couto, president of the National Academy of Medicine, Brazil, has left for Europe to deliver several lectures.

Professor Terence T. Quirke, chairman of the department of geology at the University of Illinois, has been granted leave of absence from May 1 to attend the meetings of the International Geological Congress to be held in Madrid, Spain. After the congress Professor Quirke plans to visit in France, England and Ireland.

The expedition headed by Professor Matthew W. Stirling, of Berkeley, Cal., arrived at Sourabaya, Dutch East Indies, on the steamship *Fomalhout*, on April 9. The airplane of the expedition was placed aboard and the ship has left for Macassar, Celebes. The party will explore the unknown parts of Dutch New Guinea, particularly in an endeavor to find traces of pygmy tribes.

Dr. Maynard M. Metcalf's address hereafter will be Johns Hopkins University, Homewood, Baltimore. In April, 1925, he was elected research associate in zoology, but because of duties at the National Research Council and because of a winter trip to Brazil, Uruguay and Panama for the collection of opalinid life history material he did not take up residence in Baltimore until last March.

Dr. J. R. Musselman has resumed his work in the department of mathematics in the Johns Hopkins University, after a leave of absence for the first semester which he spent in London at Pearson's Statistical Laboratory.

Professor Kirtley F. Mather, of the department of geology at Harvard University, will go to the Elk Hills, Cal., oil fields at the end of this month for a stay of about four weeks, where he will do scientific work for the federal government.

Dr. Lafayette B. Mendel, professor of physiological chemistry in Yale University, recently visited the University of Illinois where he delivered lectures on "The Proteins in Nutrition" and "The Rôle of Proteins in Growth."

Dr. Hugh S. Taylor, of Princeton University, lectured before the Northern West Virginia section of the American Chemical Society, on March 25, on "Contact Catalysis," and on March 29, Dr. James F. Norris, president of the American Chemical Society, lectured before the section on "Recent Advances in Organic Chemistry as applied to Industry."

Dr. Joseph Goldberger, of the U. S. Public Health Service, gave an address at the School of Hygiene and Public Health, Johns Hopkins University, on March 1, on "Present Status of Our Knowledge of the Etiology of Pellagra."

Professor Ross Aiken Gortner, of the University of Minnesota, lectured on "Adsorption and Vital

Phenomena," under the auspices of Washington University and the Missouri Botanical Garden, at St. Louis, on March 22; at the Iowa State University, Iowa City, on March 23; at the Des Moines Academy of Medicine on March 24, and at the Mayo Foundation and Mayo Clinic, Rochester, Minnesota, on March 25.

THE Westbrook lectures at the Wagner Free Institute of Science for 1926 were delivered during March by Professor G. H. Parker, director of the Harvard zoological laboratory. The general subject of the lectures was "The Animal Mind—Its Sources and Evolution," and the four lectures dealt with "Animal Activities as Signs of Mind," "The Senses and the Mind," "The Beginnings of Mind," and "The Characteristics of Mind in the Higher Animals."

DR. H. H. KIMBALL, physicist in charge of observations of solar radiations at the United States Weather Bureau, lectured before the Franklin Institute, on April 15, on "Solar Radiation and Weather Forecasting."

DR. EDGAR JAMES SWIFT, of Washington University, will lecture before the postgraduate school of the U. S. Naval Academy at Annapolis on April 24. His subject will be "An Efficient Mind."

M. HENRI CORREVON, of the Jardin Alpin at Geneva, Switzerland, recently visited the University of Colorado. He lectured on alpine flowers in Denver.

A MEMORIAL tablet to Dr. Thomas Corwin Mendenhall, the distinguished physicist, third president of the Worcester Institute of Technology, will be dedicated on June 19. Dr. Mendenhall was president of the institution from 1894 to 1901.

DR. MAX D. KAHN, director of laboratories in the Beth Israel Hospital and associate in biochemistry at Columbia University, died on April 8, aged thirty-nine years.

DR. HAROLD WILLIAMS, dean emeritus of the Medical and Dental Schools of Tufts College, died on April 3, aged seventy-three years.

THE death is announced of Dr. L. Testut, emeritus professor of anatomy at the University of Lyon.

DR. W. E. HOWARTH, of the London School of Hygiene and Tropical Medicine, has been killed in an automobile accident in Southern Rhodesia, where he had gone under the auspices of the school to undertake research in medical entomology. Dr. Howarth was sixty years old.

THE Providence meeting of the American Society of Mechanical Engineers will take place from May 3 to 6.

THE Boylston prize committee of the Harvard Medical School has voted that none of the essays submitted are worthy of the prize. Essayists may have the return of their essays by notifying the secretary, Dr. Henry A. Christian, Peter Bent Brigham Hospital, Boston, of the legend on the essay and the address to which it is desired that the essay be sent.

A CORRESPONDENT writes of Bulletin 140, "Key-Catalogue of the Protozoa reported for Man," and Bulletin 142, "Key-Catalogue of the Worms reported for Man," prepared by Stiles & Hassall, have recently been issued by the U. S. Public Health Service. The demand for these keys has been so extensive that the original editions have been entirely exhausted. Congress has already reprinted Bulletin 142 in a Congressional Edition, as House Document No. 16. Zoologists and physicians interested in the two bulletins and wishing to obtain copies should write to their congressmen giving the exact references, namely Bulletins 140 and 142, Hygienic Laboratory, and should refer also to House Document No. 16.

DR. FRANKLIN H. MARTIN, of Chicago, director-general of the American College of Surgeons, has announced that arrangements have been concluded with the Panaman Hospital authorities for allocating temporary laboratory space in the International Hospital to enable the Gorgas Memorial workers to begin research work in tropical diseases and preventive medicine. The laboratory space will be maintained pending the erection of a permanent laboratory for the Gorgas Memorial. Professor Richard P. Strong, of Harvard University, will be in charge of the laboratory.

PRELIMINARY steps toward the foundation in New York City of a Museum of the Peaceful Arts, for which the late Henry R. Towne left a bequest of over $1,000,000, are being taken through visits of American scientists and industrialists to Europe to inspect similar institutions there and gather information helpful to the project. Elmer A. Sperry, electrical engineer and inventor of the gyro-compass, and Dr. Calvin W. Rice, secretary of the American Society of Chemical Engineers, have already departed on such a quest. At a later date John W. Lieb, vice-president of the New York Edison Company, will make a similar trip, specializing in the study of light, heat and power exhibits. Other eminent engineers who are booked to help the movement by personal investigation abroad are Ambrose Swasey, who established the Engineering Foundation; President S. W. Stratton, of the Massachusetts Institute of Technology, and Dr. H. Foster Bain, formerly director of the U. S. Bureau of Mines.

The American Journal of Science, founded in 1818, has been turned over to Yale University by Professor Emeritus Edward S. Dana, '70, and will now become an integral part of the educational activities of the

university. Yale, in cooperation with Professor Dana, will continue to publish it as a scientific journal, covering the broader fields of sicence. The journal will be conducted by a committee appointed by the university, consisting of Professor Alan M. Bateman, chairman, Provost Henry S. Graves, Dean Charles H. Warren and Professor Edward S. Dana. The active editorship will be continued by Professor Bateman cooperating with Professor Dana. Dr. Ernest Howe, of New Haven and Litchfield, has been appointed editor of the journal by the university, and after he has had an opportunity to become acquainted with the editorial details will assume the active editorship.

WE learn from *Nature* that the first number of a new Russian periodical, ***Journal de Biologie et de Médecine expérimentale,*** published by the State Scientific Institute of the Commissariat of Public Health in Moscow, has been issued. The journal is devoted to experimental works in physiology, general pathology, bio-chemistry, bio-physics, microbiology and allied sciences. The editorial committee, under the directorship of Professor B. Sbarsky, consists of the following: A. Bach, P. Diatropoff, N. Koltzoff, P. Lazareff, L. Tarassevitch and M. Schaternikoff, with Professor I. P. Pavlov as one of the chief collaborators. The main object of the journal is to unite in one publication the original works appearing in Russia and hitherto scattered amongst the special biological and medical periodicals.

THE Russian Society for the Study of the Urals, Siberia and the Far East is publishing, in conjunction with the All-Russian Central Executive Committee for Assistance to Northern Tribes, a new periodical, *North Asia,* devoted to the study of the northern Asiatic territories of Russia. The journal has the support of the Chief Department of Scientific Institutions (Glavnauka) and is edited by V. Vilensky-Siberiakov. The main object of the new journal is the investigation of the economic problems of Siberia and the amelioration of the position of its native tribes. All the articles are written in Russian and are not provided with summaries in a foreign language, only the title of the journal and the table of contents being translated into English.

IT is announced that the British *Journal of Physiology* will be conducted in future by the Physiological Society, which has appointed an editorial committee of four. The change has been rendered necessary by the death of Professor J. N. Langley, who had been responsible for the editing.

DR. HAROLD C. BRYANT, economic ornithologist in the University of California, Museum of Vertebrate Zoology, and director of education and research for the California Fish and Game Commission, will again be in charge of the Yosemite Nature Guide Service during the coming summer. Through the cooperation of the California Fish and Game Commission with the National Park Service, and under the title of Nature Guide Service there has been instituted an educational program for the visitors to this national park. Headquarters are established at the new Natural History Museum furnished by the Laura Spelman Rockefeller fund and through a program of lectures and field excursions, vacationists are instructed regarding the fauna and flora of the park and the means to be taken to conserve it. Last season the lecture attendance amounted to more than 50,000, and nearly 10,000 persons were taken on field excursions. Last summer Dr. Bryant helped to establish a school of field natural history designed to give needed training in field studies to teachers of natural history and to nature guides. This school will begin its second session on June 21. Six weeks are spent in Yosemite Valley and a seventh week is devoted to studies at timberline.

ACCORDING to the London *Times* Sir Frank Heath, secretary of the British Department of Scientific and Industrial Research, has presented a report to the Australian Parliament in which he recommends the reorganization of the Australian Institute of Science and Industry under an advisory council. He recommends that the cost should rise from £40,000 in the first year to £100,000 in the third year. He urges the establishment of a trust fund of £100,000 to assist in training young Australians for research and suggests that Great Britain and Australia should exchange scientific officers. It is stated that the government intends to give effect to the recommendations.

A PROJECT for the preservation of the fauna of South Africa has been launched at Capetown. Resolutions have been adopted in favor of introducing legislation to create a "National Kruger Park" in the area now known as the Sabie Reserve in the Transvaal. This is the home of lions, a great variety of buck and the finest fauna of the sub-continent. It also is hoped definitely to preserve the fauna of the Cape and Zululand on similar lines. Some speakers at the public meeting urged that the whole world, especially Great Britain and America, should join the South Africans in the preservation of the wonderful asset of one of the wealthiest countries of the world in fauna. They assured the meeting also that the proposal undoubtedly would meet the approbation of kindred societies in England and America and would be most attractive to the ever-increasing number of overseas visitors, as the park would be traversed by the railway.

A NEW building for the department of biochemistry at the Alfred Hospital, Queensland, Australia, said to equal any of its kind in Great Britain, was formally

opened on Jaunary 22, by Dr. M. T. MacEachern, of Chicago, who is in Australia surveying the hospitals. The new laboratory has nine rooms.

THE secretary of the British Department of Scientific and Industrial Research announces that the department has recently established a small research laboratory at Dudley House, Endell Street, in the vicinity of Covent Garden fruit and vegetable market. The laboratory will work in close connection with the Low Temperature Research Station, Cambridge, which is the headquarters of the fruit and vegetables section of the department's organization for food investigation. The object of the laboratory is to bring the station into closer contact with the trade in fruit and vegetables, and with the practical aspects of the problems of their transport and storage.

ABOUT $35,000,000 is spent annually by American manufacturers in research work, and probably $500,000,000 annually is saved as a result of such researches, according to estimates given by the United States Chamber of Commerce. Describing some of the principal research activities now in progress, the chamber said that the majority of trade associations were spending above $20,000 each annually in cooperative research, while expenditures by large corporate units are much more. The National Canners' Association reported $120,000 as its yearly research budget, while the Portland Cement and National Lime Associations each accounted for $100,000. Large permanent investments in laboratories also were reported.

THE *Journal* of the American Medical Association states that the new state serologic institute at Utrecht was recently dedicated. During the ceremonies, Professor Aldershoff gave an account of the activities of the institute, which consist in inducing antidiphtheritic immunization by the use of the toxin-antitoxin mixture; immunization against scarlet fever ; the crusade against asthma, in which Dr. Pondman is engaged, by means of a polyvalent autovaccine; the preparation and study of pertussis vaccines, and the new findings of Calmette and Guérin concerning vaccination against tuberculosis with BCG. Following the dedicatory address, Minister Aalberse gave the history of the institute, which was founded originally as a private enterprise of Dr. Spronck, before it became the annex, that it now is, to the central laboratory and to the University of Utrecht.

UNIVERSITY AND EDUCATIONAL NOTES

IT is announced that more than $8,000,000 have already been subscribed to the $10,000,000 fund sought for building the University of Miami, Florida.

A CAMPAIGN is under way to raise $5,000,000 for a new university in Kansas City to be known as the Lincoln and Lee University. The trustees contemplate breaking ground this fall, and the beginning of class work one year from that time.

DR. OSWALD VEBLEN, professor of mathematics, has been appointed the first incumbent of the Henry Burchard Fine professorship of mathematics at Princeton University. Dr. James W. Alexander and Dr. Tracey Yerkes, National Research Fellow at Princeton, have been made assistant professors in the same department.

DR. HENRY C. HARTMAN, professor of pathology at the University of Texas, has been appointed acting dean of the medical school, to succeed Dr. William Keiller, professor of anatomy, who has remained on duty since tendering his resignation a year ago.

ROBERT DE COURCY WARD, professor of climatology, and Dr. Ralph Barton Perry, professor of philosophy, have been appointed the professors from Harvard University for the year 1926–27 under the interchange agreement between Harvard University and the western colleges.

DR. W. F. SHENTON has resigned his position at the United States Naval Academy to become professor of mathematics and head of the department at the American University, Washington.

PROFESSOR E. T. BELL, now of the University of Washington, has been appointed to the staff of the department of mathematics of the California Institute of Technology.

DR. J. H. TAYLOR, of Princeton University, has been appointed assistant professor of mathematics at Lehigh University.

DR. B. P. WATSON, professor of midwifery and diseases of women at the University of Edinburgh, has accepted the chair of obstetrics and gynecology in Columbia University, and the directorship of the Sloane Hospital for Women.

DISCUSSION AND CORRESPONDENCE

THE ISOLATION OF INSULIN

AT a meeting held on January 20, 1926, of the Society of Experimental Biology and Medicine[1] a paper was presented on the isolation and analysis of a compound of insulin with Naphtolgelb S ("Flavianic acid"). This preliminary paper, which was sent from Warsaw in December, 1925, to assure his priority in the field, can now be augmented by the following data.

[1] Proc. Soc. Exp. Biol. Med. 23, 281, 1926.

A purified insulin preparation gives with flavianic acid a compound of constant composition. This compound was converted into insulin flavianate-picrate, then into picrate, hydrochloride and finally pure insulin. The composition of all these five compounds, which can be recrystallized and are often obtained in a form of spherolytes, shows a chemical composition on analysis which agrees one with each other. It can be reasonably assumed, therefore, that the insulin obtained in this way represents a chemical entity. The most simple empirical formula for insulin obtained from dozens of analyses is $C_{69}H_{102}O_{22}N_{18}S$, and the molecular weight therefore is equal to 1,565. The structure of the compound will probably be one of a polypeptide composed of about fifteen aminoacids. It must be conceded, however, that dealing with such high molecular substances the analytical results agree almost as well with the formula $C_{74}H_{114}N_{20}O_{24}S$, with a molecular weight of about 1,700. It is of little importance at the present time to know which of the two formulas is right, as the synthesis of the substance appears to be far off. The convulsive dose for rabbits of pure insulin obtained in this way is about 0.08 mg and therefore the old clinical unit equals 0.026 mg. On heating pure insulin a crystalline sublimate appears which is now being investigated.

The practical benefit of the work presented here is greater uniformity of action of insulin compared with the usual insulin makes and the possibility of standardization of insulin by weighing the substance without the use of animals. The method has been also applied with success for preparation of insulin directly from pancreas without the use of alcohol. Results so far obtained yielded an insulin preparation with a clinical unit equal to 0.06 mg and it is very probable that pure insulin can be obtained in this way. The method is being applied to the isolation of other hormones of similar structure to insulin.

CASIMIR FUNK

STATE SCHOOL OF HYGIENE,
WARSAW, POLAND

MOUNT JORDAN

I NOTICE in the press that a peak in the King's Kern Divide in the High Sierras in Tulare County has been named Mount Jordan. Some thirty years ago a peak farther north, the second highest in the state, one of a series called the Palisades, was called Mount Jordan, by Professor Bolton Coit Brown, of Stanford University. This name went on the maps until Dr. John N. LeConte, in making a map of the region, discovered that the early Whitney Survey had called the mountain in a general way the North Palisade, not exactly as the name of a peak but as that of a mountain ridge. The Lieutenant Wheeler Survey which followed gave this particular crest of the mountain the name of North Palisade. The stream at the foot of the mountain flowing into the San Joaquin, I believe, is still called Jordan Creek.

Some years after, a number of us from Stanford climbed one of the high peaks of the King's Kern Divide and named it Stanford University Peak, or in short Mount Stanford. Adjoining this is a very rocky point early called Gregory's Monument, and a third peak of some 12,000 feet has remained unnamed. Dr. John N. LeConte and Mr. Francis P. Farquhar, a mountaineer prominent in the Sierra Club and chairman of the committee on names, have named this peak Mount Jordan, having the name put on the maps of the U. S. Geological Survey. Mr. Farquhar observes: "We feel that you will be particularly pleased at the selection of a peak in the region where you spent some time in 1899 and which was the inspiration for your admirable book on the Kings-Kern Divide."

I can stand it if the mountain can and I feel honored to be connected anywhere with one of the giants of the Sierras.

DAVID STARR JORDAN

STANFORD UNIVERSITY

THE PRICE OF HONOR

IT may be of interest to American scientific men to see the correspondence concerning an honor which it has been proposed to confer upon some of them.

Ph.D.

ACCADEMIA INTERNAZIONALE DI LETTERE E SCIENZE
Napoli Italia

The Vice-President
for the Americas

5, Place Vendome
Paris, France
28 Dec. 1925

My dear Colleague:

In view of your widely appreciated academic services I have taken the liberty of submitting your name for the distinction of membership in the Academy of Letters and Sciences at Naples, a body of eminent persons, originally started by forty-six "founder-academicians," almost all professors in the Royal University of Naples. Professor Dr. Pietro Amoroso, Duke of Rijéka, the President-General, advises me that your possible candidature will prove acceptable to the Academic Senate.

It may interest you to learn that Woodrow Wilson formally accepted honorary membership in the Academy. Thomas A. Edison, as well as Chancellor E. E. Brown of New York University, and President N. M. Butler of Columbia University, are among the distinguished American members.

Kindly inform me whether you will accept election, in which case your diploma and the academic medal will be posted to you directly from Naples, registered.

Expressing the hope that you will lecture before the Academy, when passing through Naples, I felicitate you upon this well-merited distinction from abroad, and remain,

Faithfully yours,

FRITS HOLM,
LL.D., D.C.L., D.Lit.
Vice-President for the Americas

To H. E. Lt.-Gen., Prof., Dr. Frits Holm, Duke of Kolachine, G.C.G., Vice-President of the Academy of Letters and Sciences of Naples, Chamberlain to His Royal Highness the Count of Casertia,

5, Place Vendôme, PARIS.

Excellency:—

In response to your recent communication I take pleasure in accepting the distinction of membership in the Academy of Naples, so graciously tendered by the Academic Senate through you.

Of the three forms of membership, namely Protector ($250.—for life), or Honorary Academician ($60.—for life), or Corresponding Academician ($25.—for life) I accept the grade of

and I do myself the pleasure of inclosing herewith bank-draft on Paris in dollars (or bills) for the amount in question, in the expectation, that you will cause my diploma and medal to be forwarded registered to the above address as soon as convenient after election.

I enclose a visiting-card, and *print* below the manner in which I desire my name and titles to appear in the diploma, and I express through you, Excellency, my thanks to the officers and members of the Academy of Letters and Sciences.

Faithfully yours,

EUGENOTHENICS

PROFESSOR HERBERT S. JENNINGS, in his timely little volume "Biology and the Advancement of Man," points out that "Heredity and environment have proven so inextricably mingled in the result that in practically no case can we claim with certainty that either alone is responsible." Since it is next to impossible to isolate the effect of heredity from that of environment, or *vice versa*, there is developing a great demand for a word which will apply to both fields of study. Since the term *eugenics* is usually construed to mean the science which deals with the improvement of the human race by selecting better hereditary qualities, and *euthenics* the study of race improvement by the regulation of the environment, neither of these terms is applicable when both fields are being considered. The term *eugenothenics* (u-jen'-o-then'-iks), which is merely a combination of the terms eugenics and euthenics, seems to supply the long-felt need. *Eugenothenics, then, is the study of race improvement by the regulation of both heredity and environment.* Many so-called courses in eugenics deal as much with environmental factors as they do with hereditary principles. They are in reality eugenothenical courses. One who is well versed in the science of eugenics and euthenics, and especially in their relationships, is a eugenothenicist.

WILLIAM M. GOLDSMITH

QUOTATIONS

RESEARCH AND TEACHING

ON the importance of promoting scientific research in America there can be no serious difference of opinion. There may, it is true, be doubts as to whether it can be "promoted," in the popular sense of the term. Certainly the qualities of mind which make research fruitful can not be manufactured to order, nor can the physical equipment which money will buy be substituted for the intellectual and spiritual gifts of nature. But such doubts furnish no ground of argument against doing all that it is possible to do. Money can not create genius, but it can give genius its tools and its opportunity. The proposals of the new "National Research Endowment," announced on February 1 by a board of trustees of which Secretary Hoover is chairman, and of which Professor A. B. Lamb, of Harvard, is a member, will, it is hoped, receive a wide and effective support. Although the published "declaration" was limited to general principles, it is said that the trustees of the endowment intend to raise a fund of $50,000,000, and that it is a part of their plan to endow research professorships at American universities. The Milton Fund for Research at Harvard, whose distribution for the next academic year is announced in our present issue, serves a similar purpose. It enables members of the faculties at Harvard to secure the time and the means of conducting research while continuing as members of an institution for higher education.

There have been signs in recent years of a tendency to establish independent agencies for research, and thus to divorce research from teaching and from the university environment. There is reason to believe that such a tendency, if carried far, would be a serious mistake. The university is the natural breeding-ground for scientific interests. In the long run the teachers will have to be relied upon to furnish the scholars, both in their own persons and in the pupils to whom they impart their spirit and method. To build up a new personnel for research would leave the teaching profession as overburdened as ever, and would cut off one of the principal hopes of relief. To accentuate the division between teaching and research would be equally bad for the mere teacher and for the mere man of research. The former would lose in freedom and incentive and in the power to

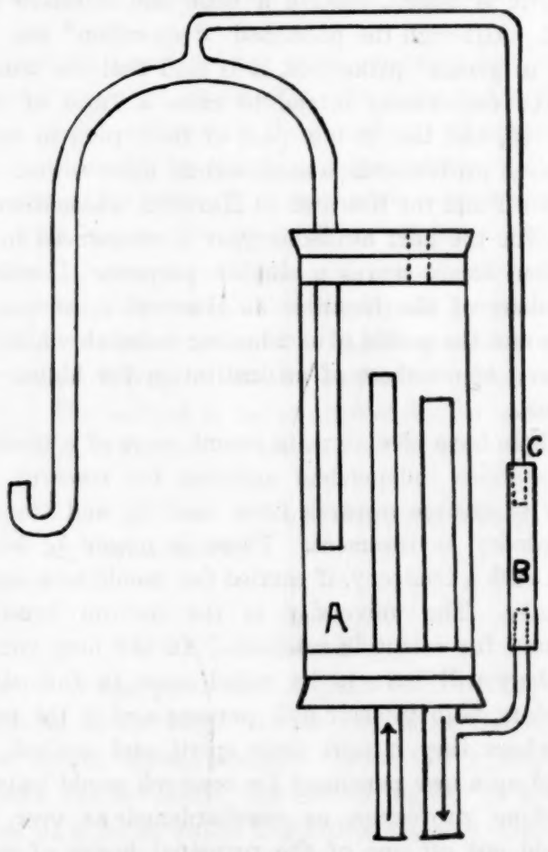
impart the spirit of creative inquiry. The latter would lose his contacts with the great intellectual tradition, with his colleagues in allied branches of knowledge, and with students who furnish both criticism and discipleship. The university is the proper center of scholarly endeavor, where are focussed the influences of history and culture, and where the achievements of maturity are renewed by the enthusiasm and forward-look of youth.

It is quite true, as asserted in the declaration of the National Research Endowment, both that facilities for research are inadequate, and that the demands of teaching and administration in American universities are excessive. It is to be hoped that both the problems will be met at the same time, and that the public interest in promoting research will be so directed as to improve the lot of those whose duty it is to teach and administer.—*Harvard Alumni Bulletin.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MODIFIED CONSTANT-LEVEL REGULATING DEVICE

ABOUT a year[1] ago a satisfactory device for maintaining a constant liquid level in any open vessel



such as a beaker was described. Employing the same principle the construction may be simplified so as to require a minimum of glass blowing. The accompanying figure elucidates this adequately. Tube A is one inch by three inches and the outlet tube is somewhat larger than the inlet. Tube C is of small bore. To start the regulator the small bore rubber tube is removed and suction applied at C. Once the siphon is started the rubber tube is replaced.

R. L. STEHLE

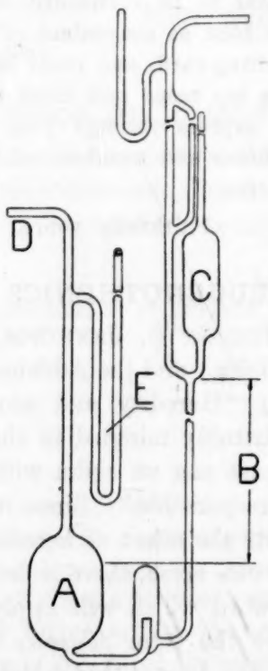
MCGILL UNIVERSITY

[1] *Journal of Industrial and Engineering Chemistry*, 17, 466 (1925).

AN IMPROVED MCLEOD GAUGE

THE writer recently had occasion to install a McLeod gauge in a production unit. Having, in the past, experienced some trouble with the usual flexible tubing type and having learned from experience that the average workman is incapable of handling the Bailey[1] model, a modified form was made. This gauge has the advantage of being all glass, does not require an aspirator and is simpler to operate than certain other models.

Referring to the figure, the gauge proper is of the usual construction. A is a reservoir containing sufficient mercury to completely fill the gauge. The distance B is made about thirty-one inches, slightly more than atmospheric pressure.



In operation, the mercury is forced into the chamber, C, by the application of air pressure through a three-way stop-cock (not shown) attached to pipe D. In the present instance the low pressure air supplied in the factory was used with a reducing valve. In order to preclude any possibility of mercury being forced into the system being exhausted, open arm manometer E was designed to act as a safety valve.

[1] Austin Bailey, *Phys. Rev.*, Vol. 15, No. 4, page 314, April, 1920.

The difference in mercury levels obtainable in this manometer is made slightly greater than the pressure required to force the mercury to the proper level in the capillary of the gauge.

In cases where compressed air is not available, a rubber atomizer bulb with a convenient releasing valve, such as is used by physicians with sphygmomanometers, will be found very satisfactory.

BRADFORD NOYES, JR.

RESEARCH LABORATORY,
TAYLOR INSTRUMENT COMPANIES,
ROCHESTER, N. Y.

SPECIAL ARTICLES

EXCITATION POTENTIALS OF THE SPECTRA ARGON II AND NEON II[1]

A PAPER now being written by the author gives some critical potential data obtained by a new method. The photo-ionization produced by the radiation from a thermionic discharge was measured by the effect of the photo-ions on the space charge in a second thermionic unit in the same tube but electrically shielded from the discharge. The present note covers only the results bearing on the excitation of the rare gas spark spectra. Argon showed three sharply defined increases in photo-ionization at $32.2 \pm .2$, $34.8 \pm .5$ and $39.6 \pm .5$ volts. The first point measures a spark excitation potential, the second gives the work required to remove two electrons (each from a 3_2 orbit), while the third point probably measures the work required to remove one 3_1 electron. Spectroscopic studies by Dejardin[2] and others show that the second spectrum of argon appears in a low current discharge, near the second point. With higher currents this spectrum is excited near nineteen volts, the difference being equal to the first ionization potential. This furnishes definite evidence that the second spectrum is a first spark spectrum and gives the basis for the above interpretation of the critical potentials. Photo-ionization measurements in neon showed two critical potentials at 48.0 ± 1 and 54.9 ± 1 volts. For the interpretation of these points it was important to know the excitation potential of the neon II spectrum. Merton[3] discovered this spectrum and it has since been studied by L. and E. Bloch and Dejardin,[4] but it has never been observed under conditions of controlled voltage. I have photographed the thermionic discharge in a simple three electrode tube using currents of a few milli-amperes and a pressure of .05 mm. The second spectrum is absent at 54 volts and distinctly visible at 55. The conspicuous lines as shown by a quartz spectrograph are between 3,700A and 3,300A. I conclude that 54.9 volts measures the work required to remove two 2_2 electrons. The first ionization potential is 21.5 volts; hence, the ionization potential of the ion is $54.9 - 21.5 = 33.4$ volts. The 48 volt point probably measures the work required to remove one electron and displace another to a 3 quantum orbit of energy 26.5 volts. A 3 quantum electron in a hydrogenic ion has an ionization potential of 6 volts while the value derived from the observed potentials is $54.9 - 48.0 = 6.9$ volts. The 3 quantum states are probably the final states for all the lines between 3,700 and 3,300, while the strongest spark lines, with final state 2_2, will lie in the far ultraviolet between 470A and 370A. There will presumably be no lines of this spectrum between 1,800A and 470A. My results fail to give evidence as to the 2_1 level of neon, but lines associated with excitation from this level are to be expected in addition to the known arc spectrum and the first spark spectrum.

F. L. MOHLER

BUREAU OF STANDARDS

[1] Published by permission of the director of the National Bureau of Standards of the U. S. Department of Commerce.

[2] *Annales de Phys.*, 11, pp. 241–327, 1924.

[3] *Proc. Roy. Soc.*, 89A, pp. 447–451, 1913–14.

[4] C. R., pp. 731–733, 1925.

SAND FLOTATION IN NATURE

EARLY in July, 1925, the writer visited the Ohio River ten miles above Cincinnati. A strong, warm breeze was blowing across the dry sand and mud flats and out upon the river. To my surprise the windward third of the river's width bore films of floating sediment, each of minute thickness but several at least one foot square. The ratio of covered to exposed water was about as 1 is to 16. The floating material proved to be sand with a few flakes of dark mica, the grains roughly 0.025 centimeters in diameter. Each patch rested in a very shallow meniscus on the water surface. No oily films were seen, which might have aided in this unusual mode of transport. As I watched more and more material was brought downstream in the same manner.

This phenomenon has been recorded by Graham, Simonds and Hovey.[1] Graham found the sand floated by splashing waves against a bar in the Connecticut River. Simonds attributed the setting adrift of the sand to the undermining of sand beds bordering the stream—in this case the Llano River. Similar instances are recorded in which the sand was washed off bars on islands by tidal currents. In the case here described the writer believes the sand was blown out upon the water surface by the wind, but evidence is not conclusive.

[1] Graham, J. C., *Am. Jour. Sci.*, III, 40, 476, 1890; Simonds, F. W., *Am. Geol.*, 17, 29–37, 1896; Simonds, F. W., SCIENCE, XI, 510–512, 1900; Hovey, E. O., SCIENCE, XI, 912–913, 1900.

The sand masses sank at once when splashed with water—in other words, when completely wetted.

EXPLANATION

The explanations of sand flotation have been varied. Nordenskiold[2] attributed considerable importance to gas bubbles attached to the sand. Simonds regarded this form of flotation as a surface tension phenomenon. Recent experiments by Coghill and Anderson show that plates of glass 0.3 cm thick and of indefinite length and breadth can be floated on water if the angle of contact between liquid and solid falls between broad limits. In prisms this tendency to float is especially favored by sharp edges.[3] The forces that balance the weight of the solid are probably at least in part due to the liquid displaced and to the hydrostatic load acting upon the lower surface of the solid.

The writer attempted experimental confirmation of the favorable effect of angularity upon the tendency to float. Angular fragments of quartz up to 3/16 x 1/8 x 1/32 inch could be readily floated on tap water without care in launching. On the other hand, clean St. Peter sand, well rounded, would not float if its size exceeded forty meshes per inch (diameter about .015 inch) and floated in quantity if finer than sixty-five mesh (about .0082 inch diameter).

Two sands, one well rounded, from Millington, Illnois, the other angular, from Gallipolis, Ohio, were screened to equal sizes—between forty and sixty-five meshes. The yellowish color and angular shape of the Gallipolis sand made its grains readily distinguished when mixed with the Illinois sand. Equal quantities by weight of the two sands were thoroughly mixed and dropped upon a water surface. Microscopic counts of the floated and sunk grains were made to determine the ratio of angular to round grains in each.

TABLE I

SHOWING RATIOS OF ANGULAR TO TOTAL GRAINS FLOATED AND SUNK

Experiment number	Total number grains counted	Per cent. angular grains among those floated	Per cent. angular grains among those sunk
1	4006	57.4	42.6
2	3925	56.0	44.0
3	3109	63.4	36.6

It is seen that angularity and hence probably also the orientation of the grain when it strikes the water surface are potent factors in flotation.

It was also found experimentally that the tendency to float decreases with the height of fall of the sand before striking the water surface.

[2] Nordenskiold, E., *Nature*, Jan. 18, p. 278, 1900.

[3] Coghill, W. H., and Anderson, C. O., U. S. Bur. Mines, Tech. Pap. 262, 27–30, 1923.

TABLE II.

SHOWING THE EFFECT OF HEIGHT OF FALL UPON TENDENCY TO FLOAT

Height of fall, inches	Weight of sand taken, grams	Weight of sand floated, grams	Per cent. of sand floated
2	1.726	.163	9.44
4	2.052	.077	3.75
8	1.464	.041	2.80

IMPORTANCE OF PROCESS

At first thought this phenomenon of floating sand is a mere curiosity, and its importance may be underestimated. It can, of course, only take place under favorable conditions—namely, when dry sand, having fair angularity and not too coarse, is properly launched and not sunk by waves or ripples. Further, the films are thin and at most represent only a small tonnage.

On the other hand, that sand which is so transported travels with far greater speed than material leaping or rolling along the bottom. Careful estimates suggest that in one hour about 120 tons of material are thus transported past any point on the Ohio under the conditions observed. If, on the other hand, Gilbert's data[4] are resorted to and the available measurements of depth, width and mean velocity of the river nearest the point of observations used, the mass of the sediment transported by rolling along the stream bottom is only about one twentieth as much—six tons.

A similar comparison may be drawn with the material carried in suspension and in solution. Following computations by Dole and Stabler and by Fenneman,[5] the weights of dissolved and suspended matter transported past Cincinnati in one hour are respectively 1,560 and 3,168 tons—or quantities only thirteen and twenty-six times as great as the weight carried by flotation under favorable conditions.

CONCLUSIONS

Quartz sand may be transported by floating on the surface of streams without the aid of supporting media. Under favorable conditions the quantity thus floated is appreciable—especially so because of the rapidity with which it proceeds. The floating of the grains is dependent largely upon their size, their angularity, their orientation when alighting and the height from which they fall before the impact upon the water takes place. This type of flotation is a special surface tension phenomenon.

CHAS. H. BEHRE, JR.

THE UNIVERSITY OF CINCINNATI

[4] Gilbert, G. K., U. S. Geol. Survey, Prof. Pap. 86, 91, 1914.

[5] Dole, R. B., and Stabler, H., U. S. Geol. Survey, Water Sup. Pap., 234, 89, 1909; Fenneman, N. M., Ohio Geol. Survey, Bull. 19, 77–8, 1914.